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Whitetail Dam, Whitehall Montana, Jefferson County, MT 118

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

15

WHITETAIL DAM

WHITEHALL, MONTANA

JEFFERSON COUNTY

MT 118

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prepared for:

HONORABLE TED SCHWINDEN
GOVERNOR, STATE OF MONTANA

WHITETAIL WATER USERS ASSOCIATION
(OWNER / OPERATOR)

prepared by:

HKM ASSOCIATES
BILLINGS, MONTANA

JUNE 1981

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JUNE 1981

SEATTLE DISTRICT
UNITED STATES
ARMY CORPS OF ENGINEERS

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U.S. Soil Conservation Service Comments on Draft Report

EXECUTIVE SUMMARY

Personnel of HKM Associates, under a contract with the Montana Department of Natural Resources and Conservation (DNRC), and with representation from the DNRC, the Whitetail Water Users Association (owner/operator), the U.S. Forest Service, and the U.S. Soil Conservation Service (SCS), inspected Whitetail Dam on September 29, 1980. The inspection and evaluation were performed under the authority of Public Law 92-367. Whitetail Dam is located on Whitetail Creek approximately 16 miles northwest of Whitehall, Jefferson County, Montana. A contract for dam construction was awarded in June 1921. Work was completed on the original phase in November 1921. The most recent rehabilitation was completed in 1977.

FINDINGS AND EVALUATION

Whitetail Dam stores runoff from a drainage of 18.9 square miles. The project was constructed to provide storage and regulation in support of irrigated agriculture. Incidental benefits related to the storage project are recreation, sediment trap, and floodwater detention. Active storage capacity to the spillway crest elevation (7249 feet NGVD) is 4900 acre-feet (AF). Total storage capacity to first overtopping dam crest elevation (7258.7 feet NGVD) is 21,400 AF, including 200 AF of dead storage. The dam has a hydraulic height of 29 feet and an estimated structural height of 29 feet. On the basis of criteria in the U.S. Army Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size. Based on a visual reconnaissance and engineering judgment, at least three residences, as well as roads, bridges, and agricultural land, will be affected by a sudden breach of the dam. The downstream hazard potential is therefore high (Category 1). However, no dam breach analysis or routing of a dam breach flood was made for the downstream area. The conclusions on probable damage are based on a brief field inspection and engineering judgment.

The guidelines recommend that the discharge and/or storage capacity of an intermediate-size, high downstream hazard potential dam be capable of safely handling the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Routing of the estimated PMF developed for the safety evaluation of Whitetail Dam showed that the project has the capacity for controlling the PMF.

The results of the surficial examination of Whitetail Dam generally indicate that the embankment structure has no outward signs of instability. Sufficient information is not available to

fully evaluate the stability of the dam. The downstream slope is steep and there are many surface irregularities. No sand boils or piping soils were observed. Piping potential is unknown because a description of embankment or foundation materials is not available. The location of the phreatic surface through the embankment is also unknown. The embankment material appears to have a high sand content. Seepage though the embankment is apparently being controlled. Erosion is present along the bank of the spillway return channel and the dam crest.

The project has the required storage and spillway capacity to control the full PMF without overtopping and causing the dam to fail. However, it appears the spillway does not have the capability of safely passing flows as high as those associated with the PMF without damaging the spillway and seriously eroding the downstream toe of the dam. Hence, Whitetail Dam does not meet inspection guidelines (Ref. 1).

RECOMMENDATIONS

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

Immediately develop, implement, and periodically test an emergency warning plan. Repair the embankment slope erosion and protect against further erosion damage. Make the following repairs to the outlet works: repair the concrete deterioration of the toewall structure, patch the joint between the toewall and the reinforced concrete pipe, and rearrange the riprap in the stilling basin for better bank stability. Make the following repairs to the spillway: repair the deterioration on the concrete weir structure, remove the timber debris and brush from downstream of the weir, stabilize the right bank of the spillway return channel, and rearrange the riprap at the downstream end of the spillway to provide additional protection for the dam embankment. Conduct more detailed studies to determine if high spillway discharges will damage the spillway and threaten the downstream toe of the dam embankment, and modify the project as indicated. Conduct and place on file stability and seepage analyses of the dam embankment (performed by a qualified geotechnical engineer) and modify the dam as studies indicate. Determine the position of the phreatic surface through the embankment and the effects of seismic loading as part of these analyses. Conduct periodic inspections by qualified engineers at least once every five years to check for any deficiencies, to assess maintenance, and to evaluate operation. Include an inspection of the entire outlet works and monitor the small seepage areas in the rock tunnel portion of the outlet. Maintain an active maintenance plan for the dam.

Prior to performing engineering studies and remedial construction, coordinate the work with the Montana DNRC, Dam Safety Section, to insure compliance with all pertinent laws and regulations.

Mike Keene

Michael D. Keene, P.E.

MONTANA
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REGISTERED
PROFESSIONAL ENGINEER

PERTINENT DATA SUMMARY

1. General

Federal ID Number	MT 118
Owner and Operator	Whitetail Water Users Association
Purpose	Irrigation
Location	Section 29, T4N, R5W, MPM; 16 miles northwest of Whitehall, MT
USGS Quadrangle Map	Elk Park, MT
County, State	Jefferson County, Montana
Drainage Area	18.9 square miles
Watershed	Whitetail Creek
Hazard Potential	Category 1 (High)
Size Classification	Intermediate

2. Reservoir

Surface Area at Existing Spillway Crest Elevation 7249.0 feet National Geodetic Vertical Datum (NGVD)	1020 acres
Dead Storage to Elevation 7240.0 feet NGVD (Invert of Outlet Works Inlet)	200 acre-feet
Active Storage to Existing Spillway Crest Elevation 7249.0 feet NGVD	4900 acre-feet
Flood Surcharge Storage to First Overtopping Dam Crest Elevation 7258.7 feet NGVD	16,300 acre-feet
Total Storage to First Overtopping Dam Crest Elevation 7258.7 feet NGVD (Including Dead Storage)	21,400 acre-feet

PERTINENT DATA SUMMARY
(Continued)

Reservoir Water Surface Elevation on Day of the Inspection	7243.6 feet NGVD
3. Spillway	
Crest Elevation	7249.0 feet NGVD
Type	Unregulated, trapezoidal weir
Side Slopes	Approximately 1V on 2H
Crest Width	Approximately 20 feet
Spillway Capacity (to Maximum Reservoir Pool Elevation During PMF (7256.0 feet NGVD)	1220 cubic feet per second
4. Outlet Works	
Gate	24-inch x 24-inch flange back slide gate valve
Control	Manual operator
Pipe	30.5 feet of 27-inch diameter reinforced concrete pipe (RCP), 30.1 feet of rock tunnel, and 60.0 feet of 30-inch diameter RCP.
Capacity	
To Spillway Crest Elevation 7249.0 feet NGVD	68 cubic feet per second
To Maximum Reservoir Pool Elevation During PMF (7256.0 feet NGVD)	81 cubic feet per second

PERTINENT DATA SUMMARY
(Continued)

5. Dam

Type	Earth fill
Structural Height	29 feet (estimated)
Hydraulic Height	29 feet
First Overtopping Dam Crest Elevation	7258.7 feet NGVD
Crest Length	Approximately 352 feet
Existing Dam Crest Width	Varies from 22 to 35 feet
Existing Upstream Dam Slope	1V on 2H down to the riprap, riprap slope 1V on 11H from top of riprap to waters edge
Existing Downstream Dam Slope	Varies from 1V on 2.7H to 1V on 1.4H

Note: The September 29, 1980 survey was based on the right (south) side of the spillway crest (elevation 7249.4 feet NGVD) as indicated in SCS project files and as written on the spillway wall.

CHAPTER 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority

This report summarizes the Phase I inspection and evaluation of Whitetail Dam. The project is owned, operated and maintained by the Whitetail Water Users Association.

The National Dam Inspection Act, Public Law 92-367 dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive concensus of the engineering community.

Where necessary the guidelines recommend a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam

(2) based upon an evaluation of the available data and a visual inspection

(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted

(4) not intended to include extensive explorations, analysis or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase

II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective action.

The responsibility for implementation of these Phase I recommendations rests with the State of Montana, Department of Natural Resources and Conservation (DNRC), and the owner. The operator is urged to contact the Montana DNRC prior to taking any action on report recommendations. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act, shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

The investigation process allows for report review by: the U.S. Forest Service; the U.S. Soil Conservation Service (SCS); the Montana DNRC; and the Whitetail Water Users Association (owner/operator). Review comments are considered before final publication of the Phase I Inspection Report. Written comments are enclosed in Appendix E.

1.1.2 Purpose and Inspection

The findings and recommendations in this report were based on visual inspection of the project, minimal field survey measurements, and review of available design and operation data. The purpose of the inspection is to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

The visual inspection of Whitetail Dam was made on September 29, 1980. HKM Associates personnel who attended the field inspection and contributed to this report were:

Dan Dyer, Geotechnical Engineer
Gary Elwell, Hydraulics/Hydrology
Mike Keene, Hydraulics/Hydrology, Team Leader

Other HKM personnel contributing to the report but not attending the field inspection were:

Dale R. Cunnington, Structural Engineer
Dan Nebel, Geology

Other personnel present during the September 29, 1980 inspection included:

Lelland Johns, Whitetail Water Users Associaton
Glen Malmquist, United States Soil Conservation Service
Larry Tegg, Dam Safety Engineer, Montana DNRC, Dam Safety Section
Norman Ward, United States Forest Service

1.2 DESCRIPTION

1.2.1 General

Whitetail Dam is an earth fill dam located in the W 1/2 of Section 29, T4N, R5W, MPM, Jefferson County, Montana (Appendix A, Ref. 2, 3, 4, and Photo 1 of Appendix B).

The dam and reservoir form an irrigation storage facility within the Missouri River Basin by containing local runoff and water from Whitetail Creek. Outlet releases are returned to Whitetail Creek. Whitetail Creek is joined by Little Whitetail Creek about 12 miles downstream of the dam. The nearest downstream community is Whitehall, Montana, which is located on the west bank of Whitetail Creek approximately 16 miles southeast of the dam or 17 miles downstream of the dam. There are several homes located in the flood plain of Whitetail Creek.

The Whitetail Water Users Association owns, operates, and maintains the project.

Whitetail Dam has a hydraulic height of 29 feet and impounds 21,400 AF (including dead storage) at the first overtopping dam crest elevation (elevation 7258.7 feet NGVD). Based on visual reconnaissance and engineering judgment, at least three residences, as well as roads, bridges, and agricultural land will be affected by a sudden breach of the dam. On the basis of this information and in accordance with the Recommended Guidelines (Ref. 1), the project is classified intermediate in size and the downstream hazard potential is high (Category 1).

Whitetail Dam was constructed to provide storage and regulation in support of irrigation practices. Incidental benefits are provided for floodwater detention, sediment accumulation, and recreation. Dead storage of 200 AF is provided below elevation 7240.0 feet NGVD. Active storage to the normal pool level, or the spillway crest (elevation 7249.0 feet NGVD), is 4900 AF. An additional 16,300 AF are available for flood surcharge storage between the spillway crest and the first overtopping dam crest elevation.

An outlet works consisting of a 27-inch diameter reinforced concrete pipe (RCP), a rock tunnel, and a 30-inch diameter RCP is located about 40 feet north of the left (north) end of the dam. A trapezoidal spillway, with a crest width of 20 feet, is located approximately 130 feet north of the left (north) end of the dam.

Whitetail Dam has an upstream contributory drainage area of 18.9 square miles. The Whitetail watershed is characterized by forested mountains and upland meadows. Elevations in the basin range from 8560 feet NGVD along the divide to 7249 feet NGVD at the reservoir (Ref. 4). The reservoir is located in open, generally flat terrain (Photo 2 of Appendix B).

1.2.2 Regional Geology

Whitetail Dam is located in a large intermountain basin in the central part of the Boulder Batholith. The Boulder Batholith is an extensive granite intrusion which extends from south of Butte to Helena and from east of Deer Lodge to west of Boulder. The nature of the granite produces broad summits and smooth-surfaced valleys, very much in contrast with the rugged topographic features associated with sedimentary or volcanic ranges in the state. Pleistocene glaciation has further modified the broad nature of the area with morainal materials deposited on the higher points and lacustrine deposits in the broader intermountain valleys (Ref. 5).

1.2.3 Seismicity

Whitetail Dam is in a moderately active to active seismic zone with the majority of the region's seismic events occurring in the Southwestern Montana-Yellowstone Park area. Since 1925, Montana has experienced five shocks that reached intensity VIII or greater (Modified Mercalli Scale). The closest epicenter occurred at Three Forks and Helena, Montana which are both about 36 miles from the damsite. Numerous other shocks of intensity IV or greater have been reported within a 100-mile radius of the site (as of January, 1974). The site is located in Zone 3 of the Seismic Zone Map of Contiguous States, and it can be assumed that a major earthquake may occur within the life of the structure (Ref. 1, 6). Although the Zone Map is based on a known

distribution of damaging earthquakes, it does not necessarily reflect accurate or adequate seismic design parameters for this site.

1.2.4 Site Geology

No exploration borings or test pits were completed prior to construction. The SCS (Ed Juvan) conducted a reconnaissance inspection of the dam and submitted a trip report dated October 31, 1973 (Ref. 5). The following is wholly based on this report with some additional information included from USGS Map MF-246, Preliminary Geologic Map of the Elk Park Quadrangle, Jefferson and Silver Bow Counties, Montana (Ref. 7).

Whitetail Dam is located at the outlet of a large intermountain basin. The basin is composed of glacial lacustrine sand, silt, and gravel with local deposits of moraine, colluvium, and alluvium. Granite hummocks protrude above the basin deposits at several locations. The dam is founded on thin stream alluvium over granite (quartz monzonite) bedrock. The bedrock is traversed by well defined systems of joint planes. Decomposition due to hydrothermal weathering is evident over much of the area. Where bedrock is completely altered by hydrothermal action, it has disintegrated into a very soft granular mass.

Bedrock along the centerline of the dam is predominantly unaltered. The bedrock is very hard and competent with the joint planes tight. The rock has very high strength and low permeability. In a small area along the left abutment, some hydrothermal weathering has occurred with the rock being very soft. As a result, extensive erosion has narrowed the rock abutment.

1.2.5 Design and Construction History

The Whitetail project was initiated when Mr. T.T. Black obtained a special use permit for the reservoir site from the U.S. Forest Service in 1910. The Whitetail Irrigation District was formed on July 8, 1918 and an unsuccessful attempt was made to sell bonds to finance construction of the project. On March 4, 1920, the Whitetail Irrigation Company was incorporated, and the District and Company coexisted for several years until the District acquired all the Company's interests. A contract for partial construction of the dam was let by the Company on June 13, 1921. The contract was completed November 15, 1921 and additional work was done the following fall (Ref. 5). George E. Baker did the engineering (Ref. 3). T. Larson of Whitehall, Montana was the contractor (stated on plaque at dam). Apparently no soil tests were performed during design of the embankment and no quality control tests were made during construction.

The first description of the dam available in the design files (Ref. 5) was made May 16, 1937 and describes the dam as follows:

> "The present dam is an earth fill with a concrete core wall extending about five feet into bedrock and projecting some two to three feet above the original ground surface. The fill was placed in 1921 with wheel scrapers by building up the lower and upper toes, then washing dirt with a hose toward the center to form a sluiced core from the foundation to the top of the dam. A small steam drive pump furnished water for sluicing. The outer banks of the dam are now about 29 feet high, while the sluiced core is finished within 11 feet of the top of the fill. The approximate dimensions are, upstream slope 3:1, downstream 2:1, top width 70 feet, and crest length 330 feet (crest elevation was about 7228 1/ ."
>
> "It has always been the intent of the owners to construct the dam so that its top elevation would be 7238 1/ and the spillway crest at 7230 1/. About 30,000 cubic yards of fill has been placed and it will take approximately 21,000 cubic yards more to complete the fill to elevation 7238 1/."
>
> "The present spillway is an open cut thru a granite ledge. Erosion has cut the rock back and deepened the channel until now the opening is about 15 feet wide on the bottom and 25 feet wide at the natural ground surface. The elevation of the crest is 7213 1/, or only 13 feet above the bottom of the reservoir..."
>
> "The outlet consists of one 36" corrugated metal pipe. Two 18" circular valves are used for controls. The gate stems rise in a concrete tower at the top of which is the lifting devices housed in a small building. The 36" pipe forms a lining for a tunnel drilled thru the rock abutment at the north end of the dam."

The Irrigation District cancelled the initial bond issue and a new bond issue was authorized on September 11, 1922. The bonds could not be sold and the project could not be completed. Based on the available information, it cannot be determined whether the dam was ever raised to elevation 7238 1/ as intended (Ref. 5).

On August 5, 1944, the Whitetail Irrigation District was dissolved and the Whitetail Water Users Association was formed.

1/ local datum

A Headwaters Resource Conservation and Development Project (RC&D) was completed in 1977. This work included removing and replacing a portion of the original outlet works and placing a new blanket of loose rock riprap on the upstream face of the embankment and at the outlet of the conduit. The configuration of the embankment apparently was not changed significantly during this stage except for a flattening of the upstream slope which will be described later. The design for this rehabilitation work was done by the Soil Conservation Service (SCS). Some soil description tests were performed by the SCS (Section 2.3.1). S. Kenney of Hardin, Montana was the Contractor (plaque on dam). Construction drawings and specifications are available in the SCS design file (Ref. 5) for this stage of the construction.

CHAPTER 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

The hydraulics and structures evaluation included a review of project data and a field inspection. The field inspection consisted of photo documentation, field measurement, and a field survey of required elevations. Inspection photos are located in Appendix B, and project drawings are provided in Appendix C: the dam crest profile is shown in Exhibit C3, the outlet works plan and profile are provided in Exhibit C4, and the spillway plan and profile are included in Exhibit C5.

2.1.1 Spillway

The spillway for Whitetail Dam is located in a granite ledge approximately 130 feet north of the north (left) dam abutment. The spillway is composed of an inlet channel, a concrete weir structure, and a return channel (Exhibit C5 of Appendix C).

The spillway inlet channel is very short. The channel is trapezoidal in shape and the banks are constructed with loose rock riprap. The channel invert is sand (Photo 3 of Appendix B).

The concrete structure forms a trapezoidal weir with a crest length of 20 feet and side slopes of approximately 1V on 2H. Concrete headwalls are located on both sides of the weir. Concrete sidewalls confine the flow downstream of the weir. The channel invert immediately downstream of the weir is bedrock (Photos 3 and 4 of Appendix B).

The return channel is earthen with large boulders and generally trapezoidal in shape (Photo 4 of Appendix B). Water travels approximately 210 feet before returning to Whitetail Creek. Energy dissipation is provided by water cascading down through the boulders.

The inlet channel appears to be in relatively good condition.

The concrete structure appears to be in satisfactory condition. The field survey indicates there is an elevation difference of 0.4 foot between ends of the weir crest. A limited amount of concrete deterioration is present (Photo 5 of Appendix B). A considerable amount of timber debris is located immediately downstream of the weir crest (Photo 4 of Appendix B). No log boom is present.

The spillway return channel is in poor condition. A significant amount of erosion has taken place along the right bank of the

return channel and dense brush is present along the left bank (Photo 4 of Appendix B).

Because of the steep channel slope downstream of the weir, timber debris, dense brush, and bank erosion in the return channel should not reduce the maximum spillway capacity.

The dam embankment and spillway crest are separated by a bedrock outcrop. However, the spillway return channel passes within 100 feet of the downstream toe of the dam embankment, and high spillway discharges could cause rapid bank erosion and eventually endanger the dam embankment (Photo 6 of Appendix B).

The spillway generally operates 8 out of 10 years (Ref. 8).

Spillway hydraulic rating information was not available. Therefore, new hydraulic rating information was developed using the U.S. Army Corps of Engineers' computer program HEC-2 (Ref. 9). Calculations were performed assuming water is flowing at critical depth at Station 1 + 15 (see Exhibit C5 of Appendix C for the spillway plan and profile) and a Manning's "n" which varies from 0.013 to 0.040. Spillway capacity to the maximum reservoir elevation during the the PMF (7256.0 feet NGVD) is 1220 cfs. However, it appears that the spillway is not capable of safely passing flows this large once the sidewalls of the concrete weir structure have been overtopped (overtopping of the right sidewall, elevation 7256.1 NGVD, would result from splashing and wave action). This overtopping could cause washing away of the fill material behind the sidewalls and failure of the concrete structure. Final spillway rating data is presented in Exhibits D2 and D3 of Appendix D.

2.1.2 Outlet Works

The outlet works for Whitetail Dam is located about 40 feet north of the left (north) abutment. The outlet works consists of an inlet channel, a headworks, a 27-inch diameter reinforced concrete pipe (RCP), a tunnel, a 30-inch diameter RCP, and a toewall (Exhibit C4 of Appendix C).

The inlet channel is excavated in the bottom of the reservoir pool upstream of the pipe inlet. The reservoir pool level must be above elevation 7240.0 feet NGVD for water to enter the inlet channel. The channel is trapezoidal in shape with a base width of 10 feet and sideslopes of 1V on 0.5H. The invert slope is 0 percent for 30 feet, 33 percent for 24 feet and 1 percent for 60.5 feet starting from the upstream end.

The headwall is constructed with reinforced concrete. The wall is 24.8 feet high, 39 feet wide, and 8 inches thick. A 24-inch

by 24-inch flange back slide gate, class 35-00, with a 24-inch by 24-inch wall thimble 8 inches long, is mounted on the headwall. A trashrack constructed with No. 5 bars protects the gate. A 1.5-inch diameter gate stem extends upward to a manual gate lift at the top of the headwall. The gate lift is attached to the headwall with a prefabricated metal mounting bracket (Photo 7 of Appendix B).

A 27-inch diameter RCP is located downstream of the headwall. A 24-inch by 24-inch square to 27-inch diameter adapter is used to join the headwall and the pipe. A 2-inch diameter steel air vent is located immediately behind the headwall. The 27-inch RCP has a length of 30.5 feet, a slope of 0.0 percent, and is encased with plastic soil cement. Downstream of the pipe water flows through an unlined rock tunnel 30.1 feet long. The tunnel is located in a bedrock outcrop (granitic hummock) near the left abutment. The tunnel has a much larger flow area than the 27-inch diameter RCP located upstream. The area of the tunnel varies with a height of 5.5 to 6 feet and a width of 3 to 4 feet. A 30-inch diameter RCP is located downstream of the tunnel and has a length of 60 feet. A headwall is located at the upstream end of the 30-inch pipe and the pipe is surrounded with plastic soil cement. The 30-inch diameter RCP is supported by a full length continuous cradle (Correspondence, Appendix E).

A reinforced concrete toewall is located at the downstream end of the pipe/tunnel/pipe system. Energy dissipation is provided by a stilling basin, with rock riprap protection, in the stream immediately downstream of the toewall (Photo 8 of Appendix B).

The outlet works upstream of the gate could not be inspected due to the high pool level at the time of the investigation.

The outlet works was inspected downstream of the slide gate. The gate appeared to seat well along the entire circumference. There is minor pitting occurring throughout the total circumference of the 27-inch diameter RCP. There are four joints in the pipe and they all appear to be in reasonably good condition. There is a small amount of ponding water in the pipe. However, this is not surprising because the pipe was constructed with no slope.

In general, the rock tunnel appears to be in good condition. There is a small amount of seepage about 1 foot and 10 feet downstream of the 27-inch diameter RCP. The paving along the tunnel invert is deteriorating and exposing the natural rock. The tunnel walls were wet up to 4 feet above the invert at the time of the investigation.

The horizontal and vertical alignment of the 30-inch diameter RCP is good. The pipe interior and all joints appear to be in excellent condition.

The concrete toewall appears to be in good condition. However, some concrete chipping is present around the junction between the pipe and the toewall. There is a slight amount of erosion in the embankment slope above the toewall.

The stilling basin appears to be in satisfactory condition. There is a small amount of instability in the rock riprap along the banks. Sediment deposition is occurring downstream of the stilling basin (Photo 9 of Appendix B).

The manual gate lift is locked with a chain. On the day of the investigation the gate was closed to test its operation capability. The gate was not operated throughout its entire travel distance. However, the gate functions extremely well and there is no reason to believe the gate would not operate throughout its entire travel distance. Due to the condition of the roads leading to the dam, access to the gate would be extremely difficult during a late spring/early summer flood event.

There do not appear to be any conditions present that would reduce the maximum outlet works discharge capability. A significant amount of sediment is present downstream of the stilling basin, but it does not appear that sediment would adversely affect outlet works operation.

It does not appear that high discharges through the outlet works would endanger the dam embankment.

A usable outlet works rating curve was not available in the project files. Therefore, new hydraulic rating information was developed using the energy equation. Calculations were performed assuming a Mannings "n" of 0.013-0.040 and a tailwater elevation equal to the crown of the outlet pipe. Outlet works capacity is 68 cfs and 81 cfs to the spillway crest elevation (7249.0 feet NGVD) and the maximum reservoir pool elevation during the PMF (7256.0 feet NGVD), respectively. Complete outlet works rating information is provided in Exhibits D2 and D3 of Appendix D.

2.1.3 Freeboard

Flood routing (Section 2.2.3) indicates the dam does not overtop during the guidelines' (Ref. 1) recommended spillway design flood (which is the full PMF), and a freeboard of 2.7 feet exists for such conditions. The vertical distance from the spillway crest (elevation 7249.0 feet NGVD) to the first overtopping dam crest elevation (7258.7 feet NGVD) is 9.7 feet. A local water user indicated that a probable historic highwater level for Whitetail Dam occurred in the spring of 1975 as the result of a snowmelt/rainfall event, however, the pool level is unknown. The

observed highwater mark on the staff gage on the outlet works headwall is 7251.0 feet NGVD, or a vertical distance from the pool level to the first overtopping elevation of 7.7 feet. The vertical distance between the reservoir pool and the first overtopping elevation at the time of the September 1980 field inspection was 15.1 feet.

Whitetail Reservoir is basically oriented in an east-west direction, with the dam on the east side. The prevailing wind for this region is generally identified as being westerly (Ref. 10, 11). The reservoir location and orientation can be observed in Appendix A. Based on an effective fetch length of 1.5 miles, the minimum freeboard allowance should be about 4.5 feet (Ref. 12). The freeboard during the PMF would be 2.7 feet. However, the vertical distance between normal pool level and first overtopping dam crest elevation is sufficient to prevent overtopping by wind-generated waves.

2.2 HYDROLOGY

2.2.1 Physiography and Climatology

Whitetail Dam has an 18.9 square mile catchment area (Appendix A). In particular, the drainage area is approximately 4.0 miles long and 6.5 miles wide. The topography is comprised of forested mountains and upland meadows.

Soils in the Whitetail Dam drainage area are described as follows: "In the heavily forested area the soils belong to the Gray Wooded great soils group. These have a layer of partially decomposed forest litter over light gray leached surface soils. Where best developed, the Gray Wooded soils have darker colored and more clayey subsoils. Chestnut (dark brown) and Chernozem (black) soils are found in some of the higher valleys and in park-like areas within the forest. Some of the soils at higher elevations are shallow and weakly developed" (Ref. 13).

The regional climate is classified as continental, and characterized by abundant sunshine, low relative humidity, moderate rainfall, and wide daily and seasonal variations in temperature. However, the regional climate does not have the extreme variable pattern common to the mountainous sections west of the continental divide. The wettest part of the year in the mountains is generally from midwinter to early spring. Average annual precipitation in the Whitetail watershed is about 20 inches (Ref. 14). The average temperature at the Boulder State School (approximate elevation 4900 feet NGVD), located about 14 miles northeast of Whitetail Dam, is approximately 42 degrees Fahrenheit. Winters are typically cold, with January being the coldest month. The monthly average temperature for January at

the Boulder State School is about 20 degrees Fahrenheit. During the summer, July is typically the warmest month with an average temperature of about 65 degrees Fahrenheit (Ref. 10, 11). Average temperatures on the Whitetail Dam drainage basin may be significantly cooler than those at the Boulder State School.

2.2.2 Estimated Probable Maximum Flood (PMF)

The probable maximum precipitation (PMP) and the estimated probable maximum flood (PMF) were developed for the Whitetail drainage basin. The ratio of the reservoir area to the non-reservoir area is greater than 1 percent; therefore, the two areas were separated for the purpose of this analysis.

The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the study region.

Whitetail Reservoir is located west of the 105th meridian and east of the continental divide, hence PMP values were calculated using procedures associated with the National Weather Service's Interim Method (Ref. 15). The Interim Method provides PMP values for durations of 6 to 72 hours, with PMP values for 1 to 5 hours obtained by multiplying the 6-hour PMP value by percentages supplied by the Corps of Engineers, Seattle District. The PMP 6-hour, 12-hour, 24-hour, 48-hour, and 72-hour values were 7.0 inches, 8.9 inches, 10.6 inches, 12.2 inches and 13.4 inches, respectively. The 6-hour PMP value of 7.0 inches was multiplied by 67 percent, 78 percent, 85 percent, 91 percent, and 95 percent to obtain PMP values of 4.7 inches, 5.5 inches, 6.0 inches, 6.4 inches and 6.7 inches for durations of 1-hour, 2-hours, 3-hours, 4-hours, and 5-hours, respectively.

The 6-hour increments for the total 72-hour storm were arranged in a critical distribution using criteria presented in the National Weather Service's Hydrometeorological Report No. 43 (Ref. 16). In particular, the 6-hour rainfall increments were arranged according to pattern "e". Further subdivision of the calculated rainfall increments was required to provide compatibility with the duration of the unit hydrograph. A 10-minute unit hydrograph was chosen for Whitetail Reservoir using criteria presented in the SCS Hydrology Handbook (Ref. 17). The unit hydrograph was developed for the Whitetail Reservoir basin using the SCS method and the U.S. Army Corps of Engineers' computer program HEC-1 (Ref. 17, 18). The PMP storm was plotted in the form of a depth-duration curve for convenience in selecting incremental rainfall values. The 10-minute PMP values, within the time base of the unit hydrograph, were ordered according to the reverse pattern of the unit hydrograph ordinates.

Rainfall losses were set equal to the minimum soil retention rate of 0.08 inches/hour for type C soils (soils having slow infiltration rates) due to an assumed saturated ground condition (Ref. 13).

The runoff condition, or PMF, resulting from a PMP storm was estimated using the PMP values and the unit hydrograph approach. The resultant PMF has a peak flow of 62,300 cfs and a 72-hour volume of 9200 AF.

2.2.3 Flood Routing

The PMF resulting from the PMP rainfall/runoff event was routed through the reservoir using the computer program HEC-1 (Ref. 18). For the purpose of determining a starting elevation for the PMF, an antecedent storm was considered. A 25 percent PMF 72-hour event was chosen as an antecedent condition since it results in a reservoir elevation very near the highwater mark observed at Whitetail Reservoir. The antecedent runoff hydrograph was developed by multiplying the PMF ordinates developed in Section 2.2.2 by 25 percent. It was assumed that the PMF would begin 48 hours after the initiation of the antecedent storm. The starting reservoir pool level for the PMF event, determined by routing the antecedent runoff through the reservoir, was determined to be 7250.8 feet NGVD.

Reservoir area-storage-elevation data was obtained from the SCS project files (Ref. 5), and is provided in Exhibit D1 of Appendix D. There is a large amount of sediment downstream of the outlet works, but it is not known whether the storage capacity has changed substantially due to sediment accumulation. Whitetail Dam discharge rating data is shown in Exhibits D2 and D3 of Appendix D. Flow through the outlet works was not included in the flood routing since the slidegate would probably be closed or opened an insignificant amount for seasonal water storage/regulation.

For the purposes of flood routing and according to Phase I investigation criteria, the minimum dam crest elevation is the elevation at which overtopping of the dam will occur. This criteria assumes overtopping and failure of embankment-type dams to be coincidental. Based upon the embankment profile survey dated September 29, 1980 (Exhibit C3 of Appendix C), the first overtopping dam crest elevation is 7258.7 feet NGVD. Flood routing showed that the dam would not overtop during the PMF, however, erosion of the embankment toe may occur during the PMF or lesser floods.

2.3 GEOTECHNICAL EVALUATION

The geotechnical evaluation of Whitetail Dam included a field investigation and a search and review of project data. The field inspection consisted of photo documentation, a dam crest profile survey, slope stability observations of the dam embankment, seepage observations, and measurements of the slope angles. Inspection photos are included in Appendix B, sketches of the plan view and embankment cross section are shown in Exhibit C1 and C2 of Appendix C, and the dam crest profile survey is shown in Exhibit C3. Results of the slope angle measurements are also shown in Exhibit C1.

2.3.1 Dam Embankment

Whitetail Dam is an earth fill structure. The dam has an estimated structural height above the deepest point on the foundation surface of 29 feet and a crest length of about 352 feet. There is an open channel spillway excavated in the natural bedrock north of the left (north) abutment.

Field measurements indicate the dam crest varies in width from 22 to 35 feet (Photo 10 and 11 of Appendix B).

Drawings for the 1977 rehabilitation indicate the upstream face of the embankment was graded to 1V on 4H prior to placing the new riprap (Photos 10, 12, and 13 of Appendix B). An average slope of 27 degrees, 1V on 2H, was measured on the existing slope above the existing riprap. As shown in photos 10, 12, and 13, the riprap does not extend up to the crest. The 1977 rehabilitation drawings indicate riprap protection was provided up to elevation 7254.4 feet NGVD. There is some scattered debris evident on the upstream slope.

Field measurements of the downstream face of the dam indicate the slope varies from 20 to 36 degrees (1V on 1.4 to 2.7H). The surface of the downstream slope is very irregular and there are two roads down the slope (Photo 11 of Appendix B) as shown in Exhibit C1 of Appendix C. There is a moderate to light cover of vegetation on the downstream slope. Some burrowing animal holes were observed on the downstream face.

Drawings indicate the approximate configuration of the original embankment, however, embankment zones and materials are not described (Ref. 5).

A detailed description of the embankment construction materials is not available, however, the embankment materials were described in 1973 by the SCS (Ref. 5) as follows:

"The embankment materials are residual soils formed from the granite bedrock (quartz monzonite) of the area. These soils materials classify as SM and SM-SP under the Unified Soil Classification System. They are predominantly poorly graded sands with from 8 to 20 percent silt and clay fines."

Information obtained during this field inspection generally agrees with the SCS description of the embankment materials.

There is an area of waste fill materials located downstream of the embankment near the right abutment. These materials do not create a safety hazard.

As-built construction plans and specifications for the rehabilitation work done in 1977 are available in the SCS design file (Ref. 5). As-built plans and specifications for the earlier work on Whitetail Dam are not available.

A crest profile survey was made during the field investigation (Exhibit C3 of Appendix C). The survey shows that the maximum differential elevation along the embankment crest is about 7.6 feet. The design crest control elevation is unknown, therefore, settlements cannot be evaluated based on this survey.

Apparently no quality control tests were made during the original construction of the embankment. However, some soils classification tests were performed by the SCS prior to the 1977 rehabilitations. These included: grain-size distribution, moisture-density relationships, and Atterberg limits tests.

2.3.2 Foundation Conditions and Seepage Control

No records of test holes are available for review. Apparently no soil tests were performed during the design of the embankment.

The foundation conditions are unknown. Based on geologic features and visual inspection of the topography at the embankment locations, the dam is resting on thin stream alluvium over granite (quartz monzonite) bedrock.

Seepage

According to information in the design file (Ref. 5) there is a concrete cutoff wall extending into bedrock about 5 feet and projecting some 2 or 3 feet above the original ground surface. Apparently there is no drain system under the dam.

At the time of the September 1980 field investigation, Whitetail Reservoir was at elevation 7243.6 feet NGVD. A point source of seepage was identified at the toe of the right abutment (Photo 14

of Appendix B and Exhibit C1 of Appendix C). Seepage appeared to be emerging from the bedrock. No sand boils or piping were evident. The surface flow from this seepage was estimated to be less than one gallon per minute.

Water was seeping under Whitetail Dam and saturating the downstream valley floor area. The downstream slope of the embankment was dry at the time of our field investigation. Seepage water had ponded at several locations on the valley floor downstream of the embankment and many springs were evident through this area (Exhibit C1 of Appendix C). Surface flows from the accumulated valley floor seepage were small and could not be determined during the field investigation. It is likely that seepage increases in this area when the reservoir pool elevation rises (Exhibit C1 of Appendix C).

In conclusion, seepage does not appear to be a problem at Whitetail Dam. The seepage creates saturated foundation soils conditions. The position of the phreatic surface through the embankment is unknown. Apparently there is a cutoff wall but no drainage system under the embankment and the natural foundation and embankment soils are relatively pervious.

2.3.3 Stability

The slope angles measured during the field investigation are shown in Exhibit C1 of Appendix C. These angles were measured with an Abney Level and are approximate.

There are no material strength data available to evaluate stability of the dam. Apparently no soil tests were performed and stability calculations were not made. The location of the phreatic surface through the embankment is also unknown. There is not sufficient information available to evaluate the stability of the embankment.

No sand boils or piping soils were observed in the embankment area.

There are no outward signs of instability. However, the downstream slope is steep and there are many irregularities on the surface. The material appears to have a high sand content. The embankment stability may conform to the guidelines but further study is necessary to confirm this.

The reservoir shoreline appears stable as no major slides were observed. The shoreline is occasionally vertical, or near vertical, to heights of less than 2 feet and localized sloughing occurs due to wave action and saturated conditions.

The side slopes of the open channel spillway are in good condition, however, some sloughing and erosion has occurred.

Erosion

There are several locations along the embankment crest and slopes where rain water has run off causing erosion. At locations where water has ponded on the crest and spilled from these ponds down the slope, small erosion gullies have formed (Photos 12 and 15 of Appendix B). Presently this erosion does not create a safety hazard, however, the embankment materials are highly susceptible to erosion.

2.3.4 Rock Riprap

There is a loose rock riprap protection blanket on the upstream face of the embankment. The SCS rehabilitation work placed the riprap to its present configuration with the upper portion of the upstream slope exposed (Photos 12 and 13 of Appendix B). The existing riprap is well indurated quartz monzonite and it appears to be adequate, however, the upper portion of the embankment on the upstream slope is exposed and is highly susceptible to erosion.

2.4 PROJECT OPERATION AND MAINTENANCE

The Whitetail Water Users Association owns, operates, and maintains Whitetail Dam. The project is located on Forest Service land and the Whitetail Water Users Association has been issued a special use permit.

There is no formal operation plan for Whitetail Reservoir. Outlet works releases are made to support irrigation practices. Useable irrigation storage is about 4900 AF. Releases for irrigation are generally made from early June through September. However, in some years the project cannot be visited until July due to the condition of the access road. The project is visited a couple times a year. The watershed yields sufficient water to fill the reservoir in most years.

The Forest Service inspects the dam on a three year basis.

In 1926, 1927, 1945, and 1963 the outlet works required repairs which resulted in interruption of irrigation water releases and crop loss.

There is no formal warning plan of action in the event of dam distress.

CHAPTER 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in accordance with the inspection guidelines (Ref. 1) and the contract performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification and Safety Evaluation

In accordance with the inspection guidelines (Ref. 1), Whitetail Dam is classified intermediate in size and, based on our visual inspection and engineering judgment, it has a high downstream hazard potential. Therefore, the guidelines' recommended spillway design flood (SDF) for this project is 100 percent of the PMF. Based on reconnaissance level investigations, the project has the required storage and spillway capacity to control the full PMF without overtopping and causing the dam to fail. However, it appears the spillway does not have the capability of passing flows as high as those associated with the PMF without seriously eroding the downstream toe of the dam. Hence, Whitetail Dam does not conform to inspection guidelines (Ref. 1).

3.1.2 Dam

Except for the steep area on the downstream slope, Whitetail Dam appears to be stable. There is not sufficient information available to evaluate the stability of the embankment. The embankment stability may conform with the Recommended Guidelines but further study is necessary to confirm this. The position of the phreatic surface through the dam is unknown. Seepage does not appear to be a problem, however, there apparently is no internal drain system. The upstream slope protection appears adequate, however, the upper portion of the embankment is exposed and is highly susceptible to erosion. There is need for seismic analysis in Zone 3.

3.1.3 Spillway

The spillway inlet channel appears to be in relatively good condition. Concrete deterioration is present on the concrete weir structure. The field survey shows the spillway crest is not level. Timber debris and dense brush are present in the spillway return channel downstream of the weir. There is no log boom. Bank erosion is occurring along the right bank of the return channel. Spillway capacity to the maximum reservoir pool elevation during the PMF (7256.0 feet NGVD) is 1220 cfs.

However, it appears that the spillway is not capable of safely passing flows this large, once the sidewalls of the concrete weir structure have been overtopped (overtopping of the right sidewall, elevation 7256.1 NGVD, would result from splashing and wave action). This overtopping could cause washing away of the fill material behind the sidewalls and failure of the concrete structure.

3.1.4 Outlet Works

The outlet works appears to be in good condition. It was not possible to investigate the outlet works upstream of the gate due to the pool level at the time of the survey. The gate appears to seat well and function properly. A small amount of pitting is present in the 27-inch diameter RCP. The lining along the invert of the rock tunnel is deteriorating and a few small seepage areas are present in the tunnel walls. The 30-inch diameter RCP is in excellent condition. The toewall has a limited amount of concrete deterioration. A small amount of instability is present in the riprap on the stilling basin banks. Outlet works capacity is 68 cfs and 81 cfs to the spillway crest elevation (7249.0 feet NGVD) and the maximum reservoir elevation during the PMF (7256.0 feet NGVD), respectively.

3.1.5 Operation and Maintenance

The Whitetail Water Users Association owns, operates, and maintains the dam. There is no formal operation plan, but irrigation releases are generally made from early June through September. The dam is inspected every three years by the Forest Service. There is no formal plan of action in the event of dam distress.

3.2 RECOMMENDATIONS

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

The investigation findings require a high priority be given to the following recommendations:

(1) Immediately develop, implement, and periodically test an emergency warning plan for use in the event of dam distress.

(2) Repair embankment slope erosion and protect against further erosion damage.

(3) Make the following repairs to the spillway: repair the deteriorating areas of the concrete weir structure, remove the timber debris and brush downstream of the weir, stabilize the right bank of the return channel with riprap to prevent further erosion, and rearrange the riprap at the downstream end of the spillway to provide additional protection for the dam embankment.

(4) Make the following repairs to the outlet works: repair the concrete deterioration of the toewall structure, patch the joint between the toewall and RCP, and rearrange the riprap in the stilling basin for better bank stability.

(5) Conduct more detailed studies to determine to what extent high spillway discharges will damage the spillway and endanger the downstream toe of the dam embankment, and modify the project as studies indicate.

(6) Conduct and place on file stability and seepage analyses of the dam embankment. It is recommended that these analyses be performed by a qualified geotechnical engineer and include effects of seismic loading. The position of the phreatic surface through the embankment should be determined to aid in these analyses. Modify the dam as the study indicates.

(7) Conduct periodic inspections by qualified engineers at least once every five years to determine whether there are any deficiencies in the condition of the project, to assess the adequacy and quality of maintenance, and to evaluate methods of operation. Include an inspection of the total length of the outlet works through the embankment in this program. Monitor the small seepage areas in the rock tunnel portion of the outlet works. Inspections by the SCS and/or Forest Service should continue on a more frequent basis than once every five years.

(8) Maintain an active maintenance plan for the dam. Besides performing the maintenance work when necessary, provide adequate documentation of that work for future reference by inspection parties.

Prior to performing engineering studies and remedial construction, coordinate the work with the Montana DNRC, Dam Safety Section, to insure compliance with all pertinent laws and regulations.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D., "Recommended Guidelines for Safety Inspection of Dams". Washington, D.C., Department of the Army, May 1975.

2. U.S. Geological Survey, 15 Minute Quad Map, Elk Park, Montana 1970.

3. Montana Water Resources Board, Montana Register of Dams, Inventory Series No. 3, October 1968.

4. U.S. Geological Survey, Butte, Montana, and Dillon, Montana, AMS, Scale 1:250,000, 1977.

5. U.S. Soil Conservation Service, Whitetail Dam, Project Files.

6. Von Hake, C.A., Earthquake Information Bulletin, USGS, Vol. 10, No. 4, 1978.

7. Smede, H.W., Preliminary Geologic Map of the Elk Park Quadrangle, Jefferson and Silver Bow Counties, Montana, U.S.G.S. Map MF-246, 1962.

8. U.S. Soil Conservation Service, Whitetail, RC&D Measure Plan for Irrigation Rehabilitation, Jefferson County, Montana, October 1975.

9. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Davis, California, October 1973.

10. National Oceanic and Atmospheric Administration, Climatological Data, Montana, National Climatic Center, Asheville, N.C.

11. National Oceanic and Atmospheric Administration, Climates of the States, Volume II, "Western States Including Alaska and Hawaii", Port Washington, N.Y., 1974.

12. U.S. Bureau of Reclamation, Design of Small Dams, 2nd. Edition, 1973, Revised Reprint, 1974.

13. State Engineers Office, Water Resources Study, Jefferson County, Montana, Helena, Montana, June, 1956.

14. U.S. Soil Conservation Service, Average Annual Precipitation, Montana, based on 1941-1970 base period, Portland, Oregon, 1977.

15. National Weather Service, Interim All-Season Probable Maximum Precipitation Estimates, Missouri River Drainage West of the 105th Meridian, January 1, 1980.

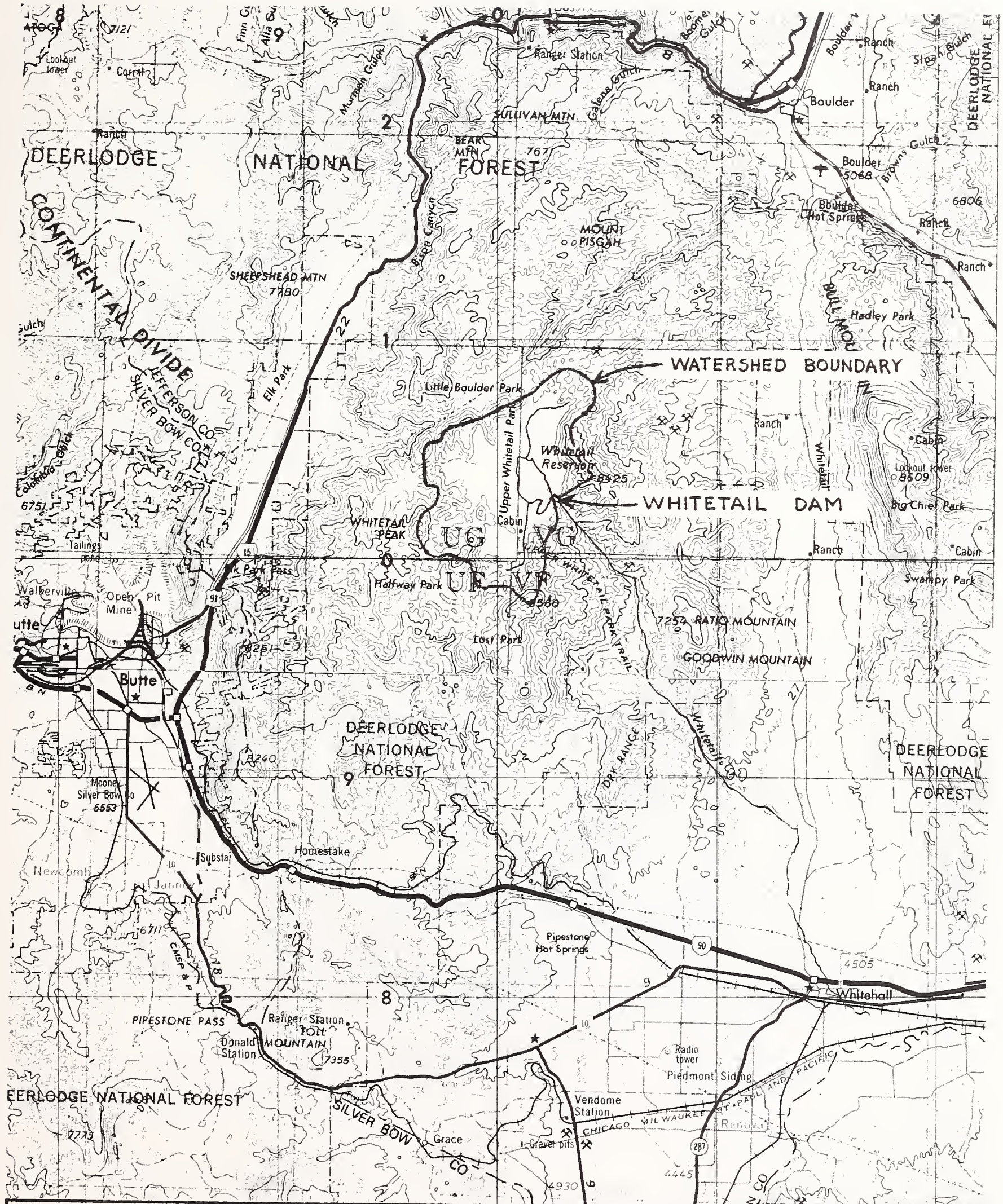
16. National Weather Service, Hydrometeorological Report No. 43, Probable Maximum Precipitation, Northwest States, Washington, D.C., 1966.

17. U.S. Soil Conservation Service, National Engineering Handbook, Section 4, "Hydrology", Washington, D.C., 1969.

18. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, September, 1978.

APPENDIX A

VICINITY & WATERSHED MAP



5 0 5 MILES

SCALE

N

SOURCE:

DILLON, MT. & BUTTE, MT
AMS MAPS, USGS

APPENDIX A
VICINITY & WATERSHED MAP
WHITETAIL DAM

APPENDIX B

INSPECTION PHOTOS

Photo No. 1 - Dam
Whitetail Dam is an earth fill structure on Whitetail Creek.

Photo No. 2 - Watershed
The Whitetail watershed consists of forested mountains and upland meadows.

Photo No. 3 - Spillway
The spillway inlet channel is trapezoidal in shape and constructed with loose rock riprap. The channel invert is sand. The concrete sharp-crested weir is in the background.

Photo No. 4 - Spillway
The concrete sharp-crested weir is located in the foreground. A considerable amount of timber debris and dense brush is located downstream of the weir. The right bank of the return channel is eroding.

Photo No. 5 - Spillway
The concrete spillway wingwalls and sidewalls are chipping, cracking, and spalling. Shown is the left wingwall and sidewall.

Photo No. 6 - Spillway
The spillway return channel (on the left) passes within 100 feet of the toe of the embankment and could endanger the dam during high spillway discharges.

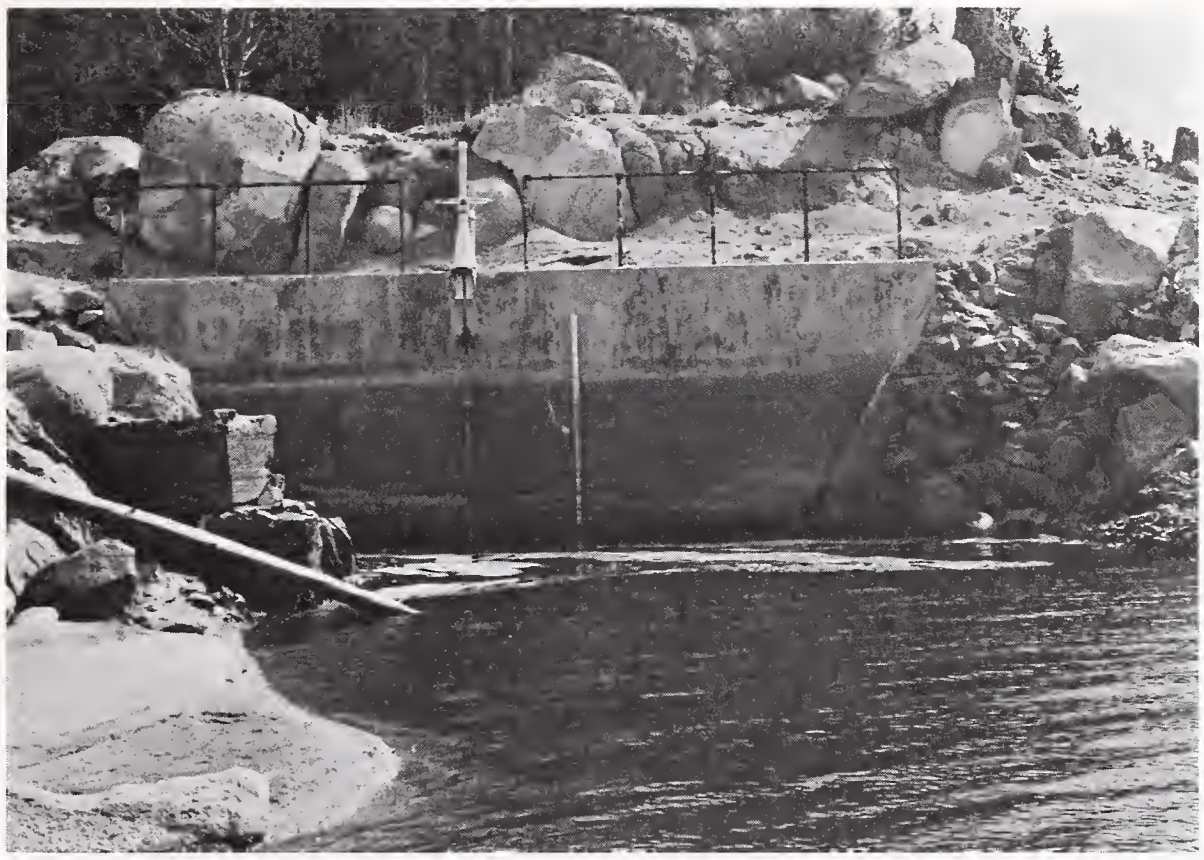


Photo No. 7 - Outlet Works
A manual lift and staff gage are mounted on the concrete headworks.

Photo No. 8 - Outlet Works
Shown is the toewall and the stilling basin. Some erosion is present in the embankment above the toewall.

Photo No. 9 - Outlet Works
Sediment has deposited in the stilling basin downstream of the toewall.

Photo No. 10 - Dam Embankment
The exposed embankment on the upstream face of the dam is highly susceptible to erosion.

Photo No. 11 - Dam Embankment
A road on the downstream face of the embankment provides access to the downstream end of the outlet works. Vegetation is moderate to light, and some pine trees are growing on the crest and slope near the right abutment.

Photo No. 12 - Dam Embankment
Erosional gullies are visible above the riprap on the upstream face of the dam embankment. Vegetation is sparse. Riprap is a quartz monzonite and there is no riprap bedding material.

Photo No. 13 - Dam Embankment
Shown is the upstream face of the dam embankment.

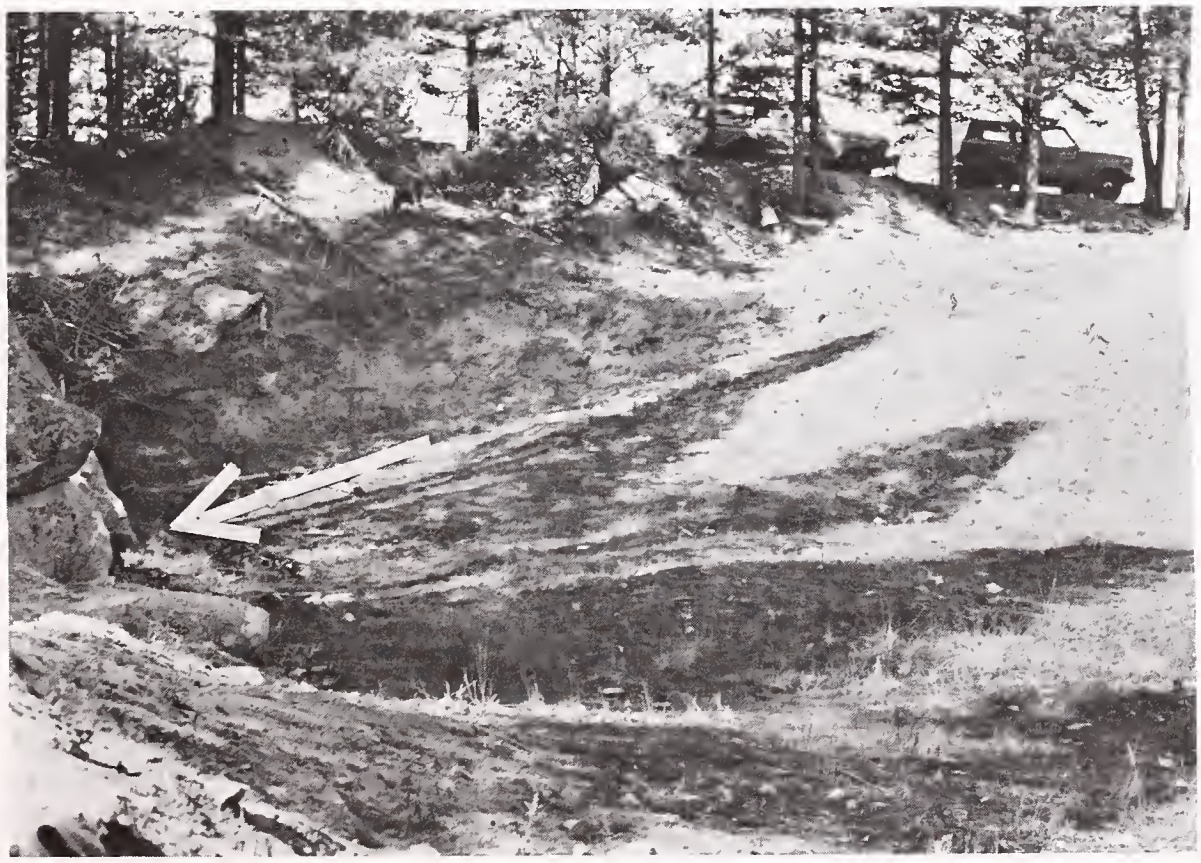


Photo No. 14 - Dam Embankment
Seepage was observed at the downstream toe of the dam near the right abutment (lower left of photo).

Photo No. 15 - Dam Embankment
Shown is an erosional gully on the downstream face of the dam. The surface material is sand and is highly erodible. Vegetative cover is light.

APPENDIX C

PROJECT DRAWINGS

EXHIBIT C1	PLAN VIEW
EXHIBIT C2	TYPICAL EMBANKMENT SECTION
EXHIBIT C3	DAM CREST PROFILE
EXHIBIT C4	OUTLET WORKS PLAN & PROFILE
EXHIBIT C5	SPILLWAY PLAN, PROFILE & SECTIONS

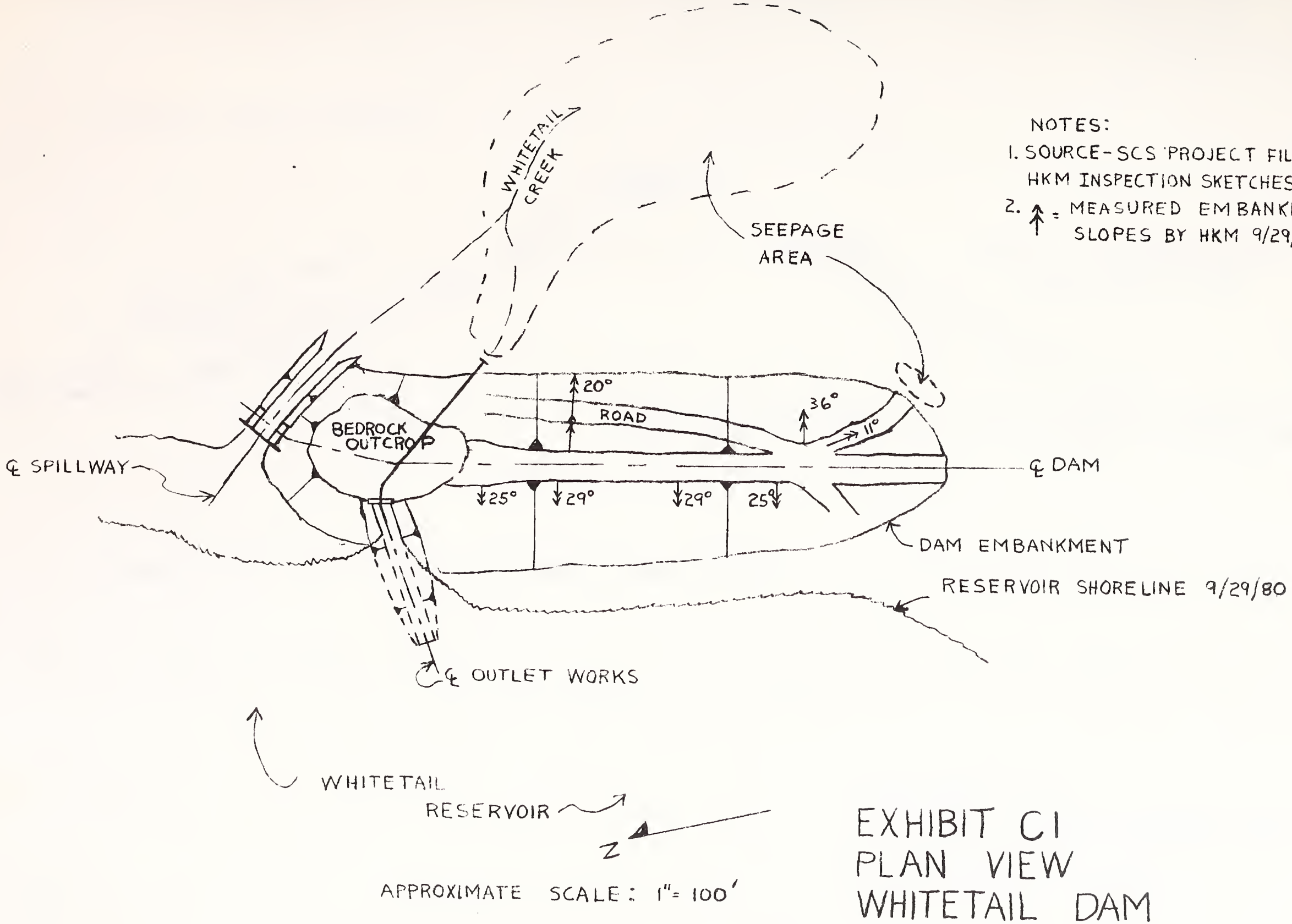
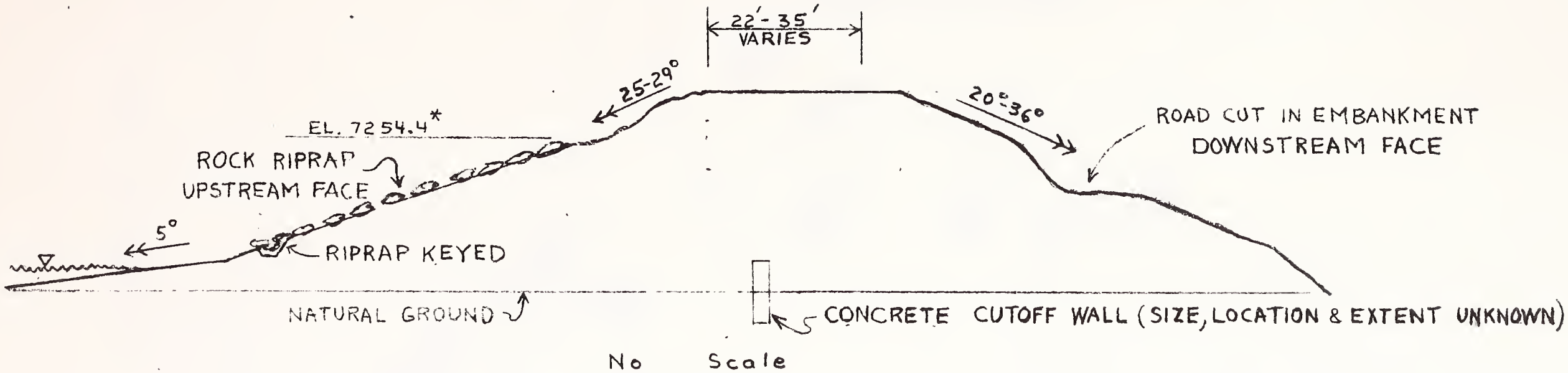


EXHIBIT C1
PLAN VIEW
WHITETAIL DAM

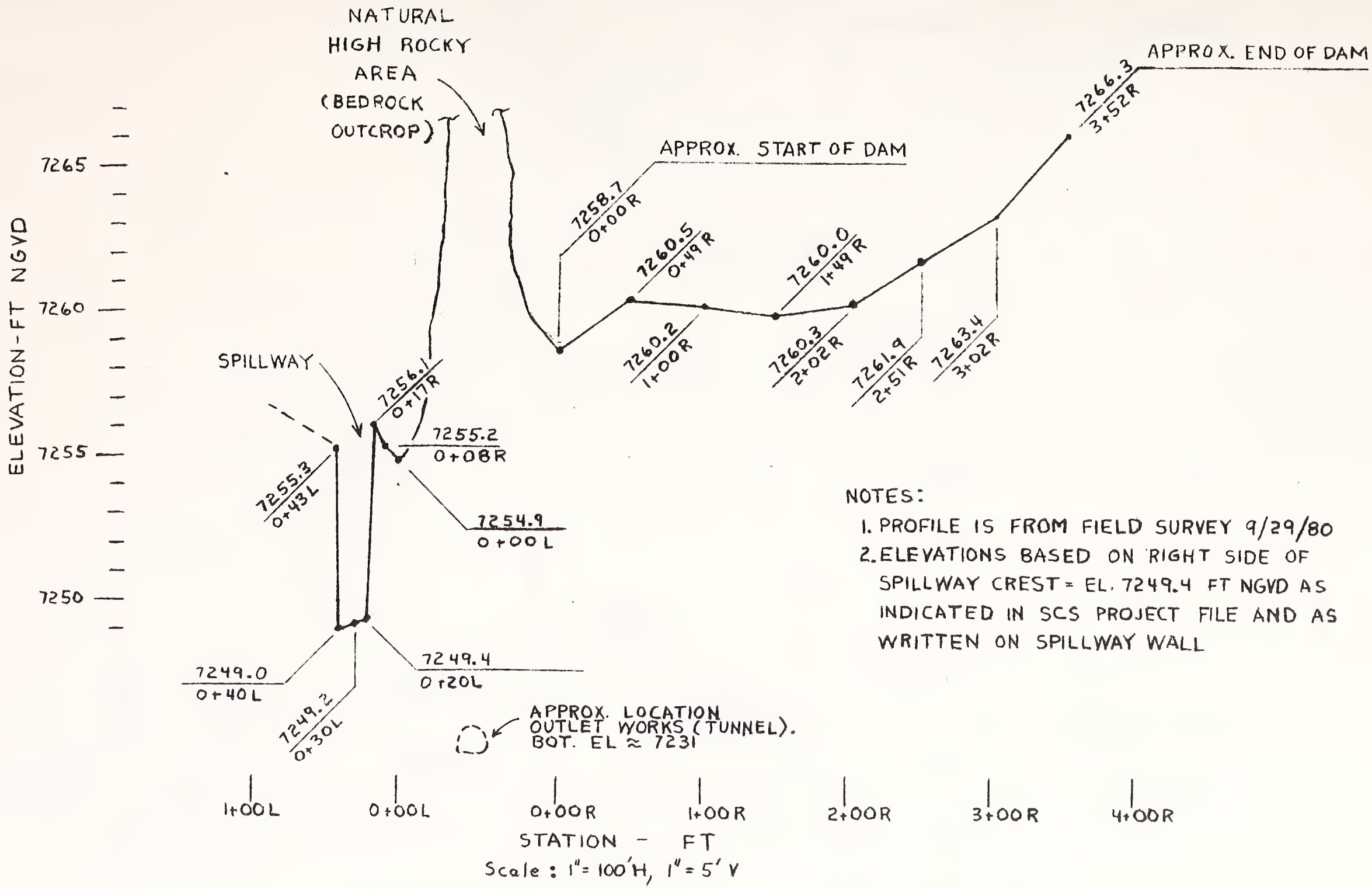
* FROM SCS PROJECT DRAWINGS



No Scale

SOURCE: HKM FIELD INSPECTION 9/29/80 UNLESS NOTED

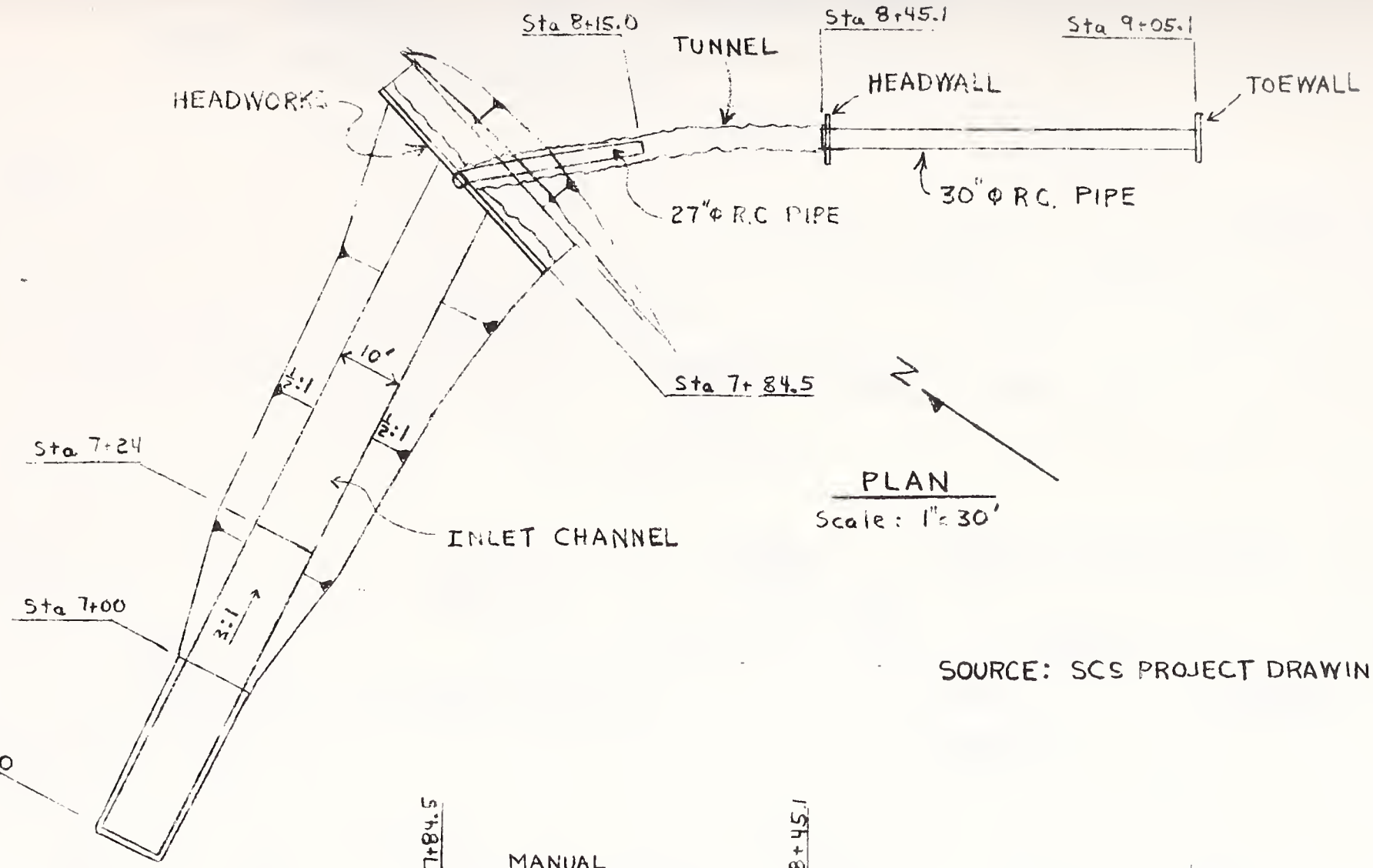
EXHIBIT C2
TYPICAL EMBANKMENT SECTION
WHITETAIL DAM



NOTES:

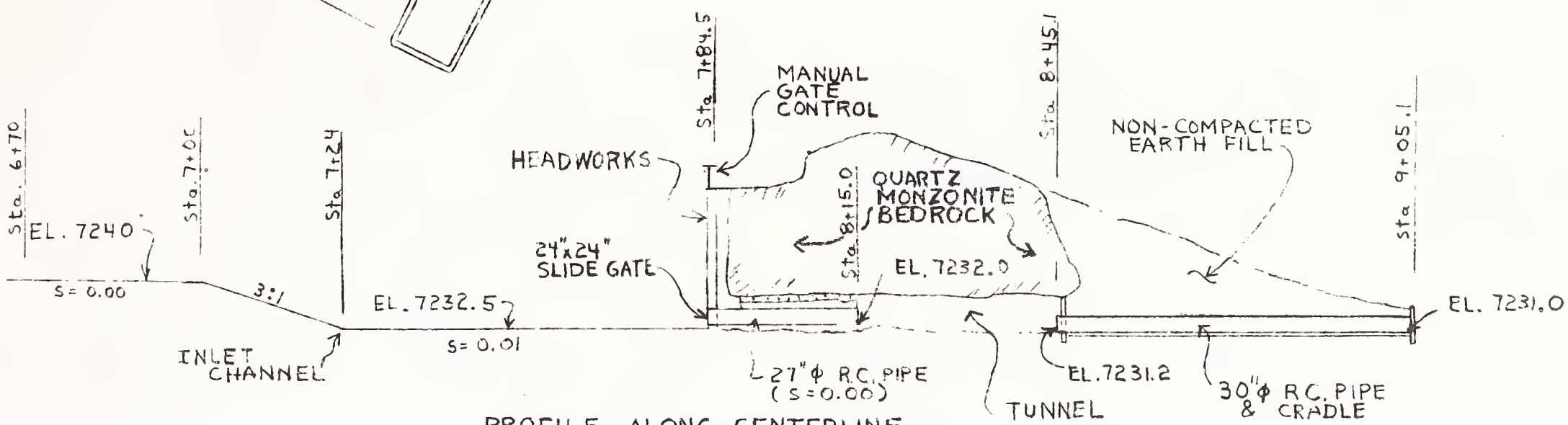
1. PROFILE IS FROM FIELD SURVEY 9/29/80
2. ELEVATIONS BASED ON RIGHT SIDE OF SPILLWAY CREST = EL. 7249.4 FT NGVD AS INDICATED IN SCS PROJECT FILE AND AS WRITTEN ON SPILLWAY WALL

EXHIBIT C3
DAM CREST PROFILE
WHITETAIL DAM



PLAN
Scale: 1" = 30'

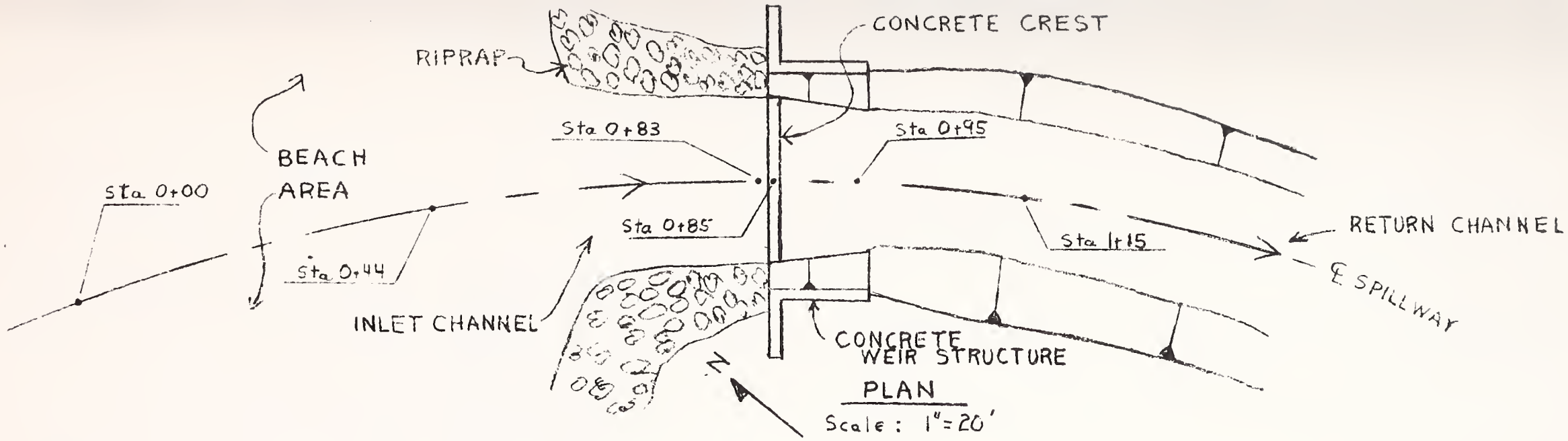
SOURCE: SCS PROJECT DRAWINGS

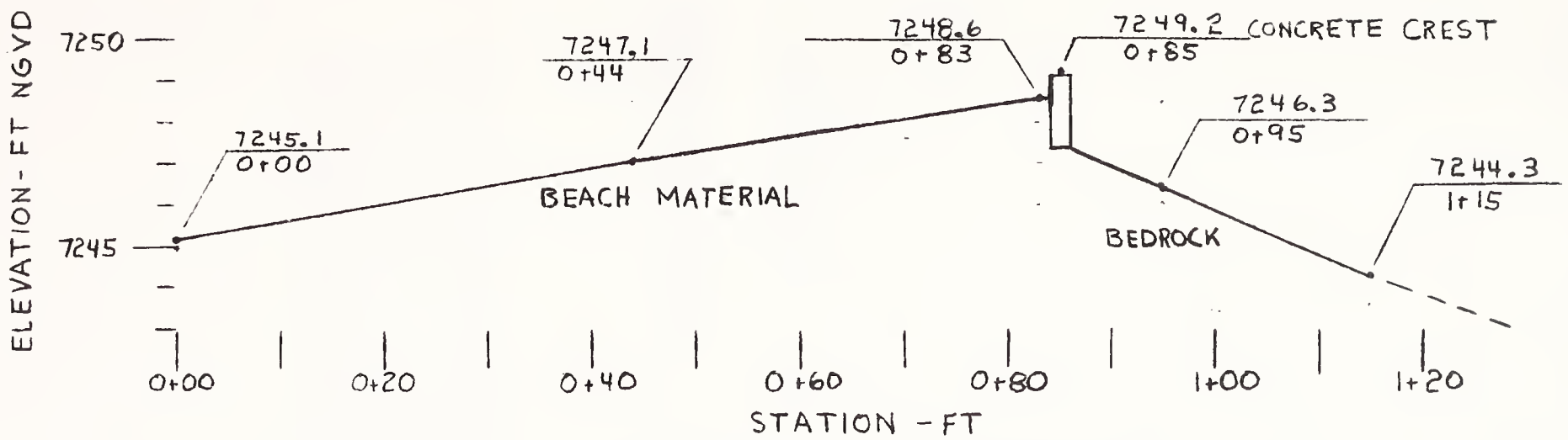


PROFILE ALONG CENTERLINE
Scale: 1" = 30'

NOTE: ALL ELEVATIONS SHOWN ARE NGVD

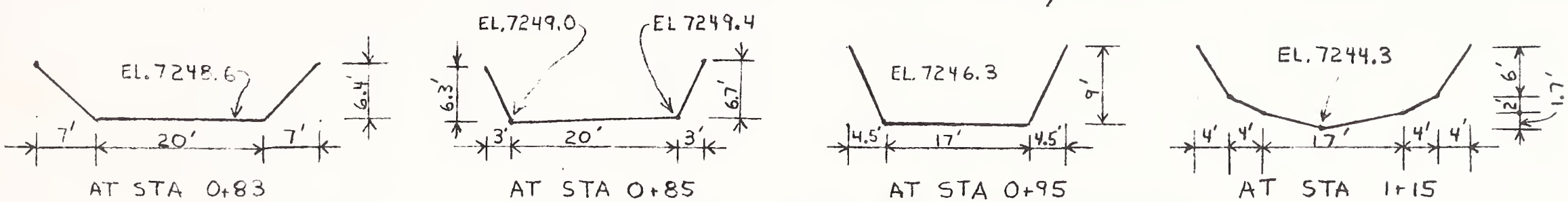
EXHIBIT C4
OUTLET WORKS PLAN & PROFILE
WHITETAIL DAM





PROFILE ALONG CENTERLINE

Scale : 1"=20'H, 1"=5'V



APPROXIMATE CHANNEL CROSS SECTIONS

Scale : 1" = 20'

SOURCE: HKM FIELD INSPECTION 9/29/80

EXHIBIT C5
SPILLWAY PLAN, PROFILE & SECTIONS
WHITETAIL DAM

APPENDIX D

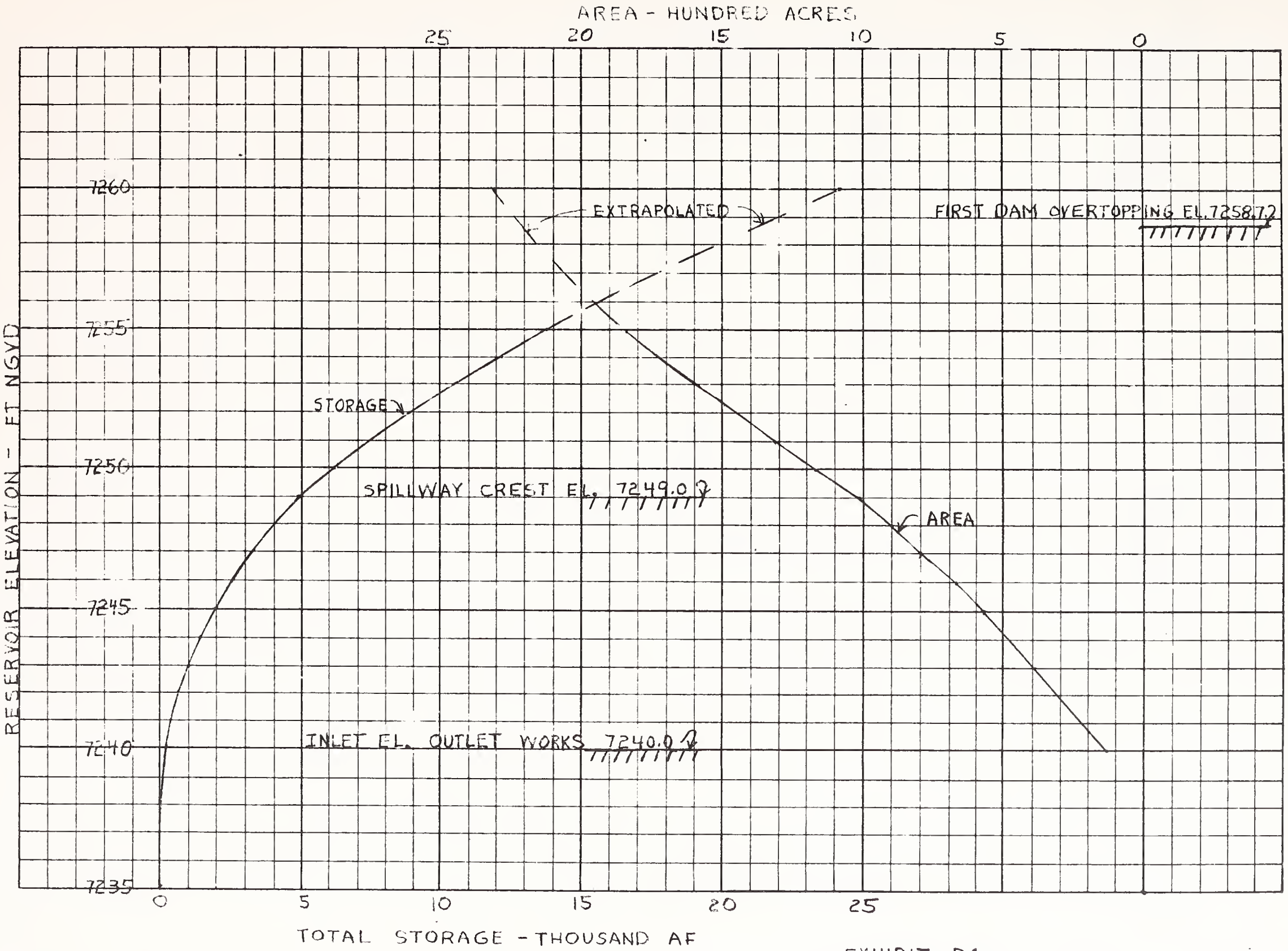
ENGINEERING DATA

EXHIBIT D1	ELEVATION-AREA-STORAGE CURVES
EXHIBIT D2	DISCHARGE RATING TABLE
EXHIBIT D3	DISCHARGE RATING CURVES

APPENDIX D

ENGINEERING DATA

EXHIBIT D1	ELEVATION-AREA-STORAGE CURVES
EXHIBIT D2	DISCHARGE RATING TABLE
EXHIBIT D3	DISCHARGE RATING CURVES



SOURCE; SCS DESIGN FILES

EXHIBIT D1
ELEVATION-AREA-STORAGE CURVES
WHITETAIL DAM

EXHIBIT D2
DISCHARGE RATING TABLE
WHITETAIL DAM

Reservoir Pool Elevation (ft. NGVD)	Outlet Works Discharge (cfs)	Spillway Discharge (cfs)
7240 (Outlet Works Inlet El.)	0	--
7241	31	--
7242	50	--
7245	58	--
7249 (Spillway Crest El.)	68	0
7250	70	50
7252	74	250
7254	78	620
7256 (Max. Pool El. During PMF)	81	1220

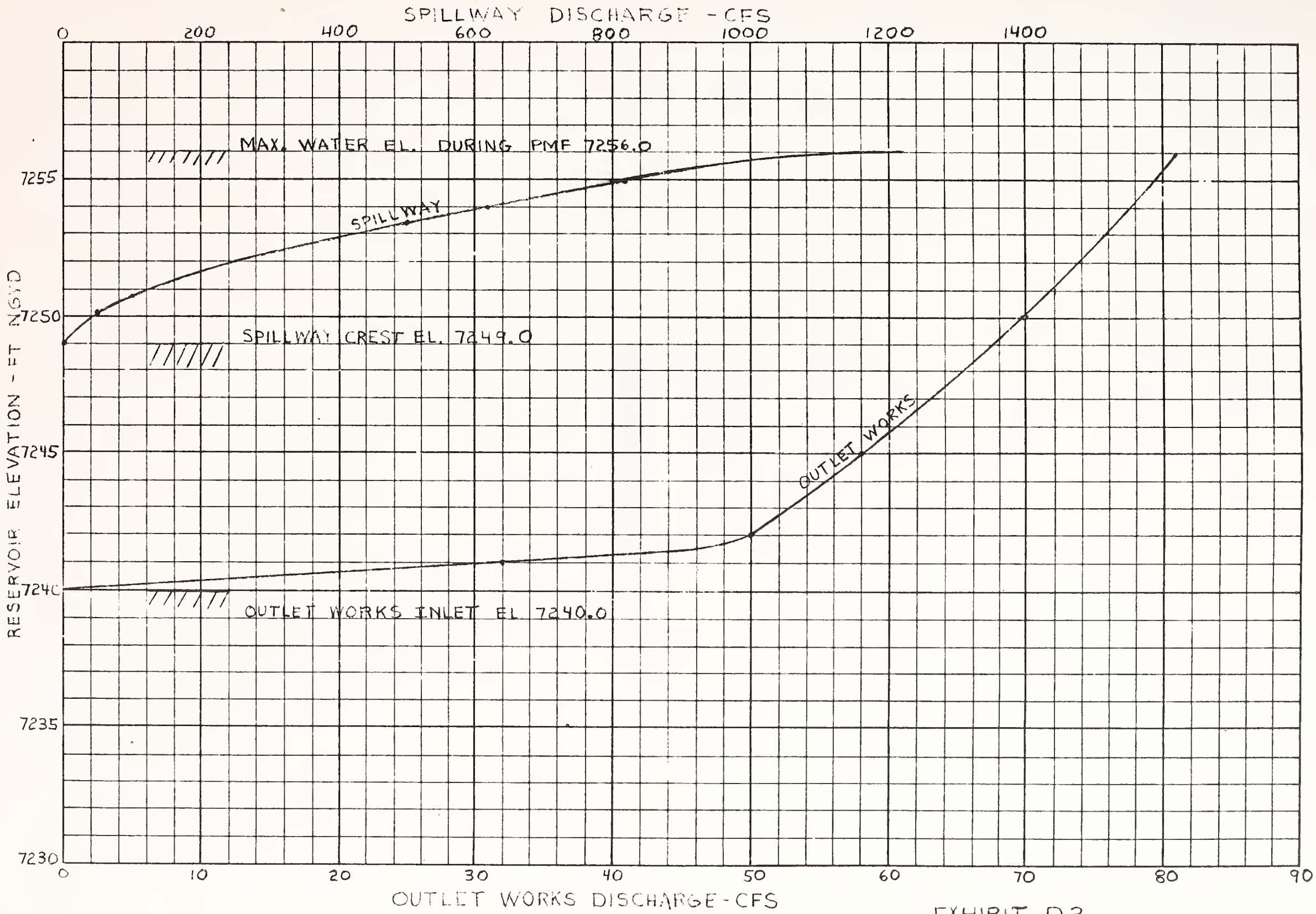


EXHIBIT D 3
DISCHARGE RATING CURVES
WHITE TAIL DAM

APPENDIX E

CORRESPONDENCE

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

TED SCHWINDEN, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872 ADMINISTRATOR
(406) 449-3962 WATER RIGHTS BUREAU
(406) 449-2872 WATER SCIENCES BUREAU
(406) 449-2864 ENGINEERING BUREAU
(406) 449-2872 WATER PLANNING BUREAU

HELENA, MONTANA 59620

May 19, 1981

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Ralph:

The Department of Natural Resources and Conservation has reviewed the final draft report on the Whitetail Dam (MT-118). We concur with the findings and recommendations and feel the report satisfies the criteria of the Phase I evaluation.

Minor editorial comments have been discussed with your staff, and we understand these will be included in the final report.

Thank you for the opportunity to review and comment on the final draft report for this project.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB:LT:lj

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59801

7530

MAY 18 1981

Sidney Knutson, P.E.
Asst. Chief, Engineering Division
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

We have reviewed the draft report on the Phase I inspection of Whitetail Dam and have the following comments.

We have classified Whitetail Dam as having a moderate hazard (equivalent to your significant hazard); and although we agree with your maintenance recommendations, we believe a detailed hydrologic analysis of a breached dam flood should be performed prior to any embankment stability studies to confirm the hazard the dam presents.

Sincerely,

Beryl Johnston

BERYL JOHNSTON
Director of Engineering

cc: Deerlodge NF

United States
Department of
Agriculture

Soil
Conservation
Service

P.O. Box 970
Bozeman, MT
59715

June 1, 1981

Sidney Knutson, P.E.
Assistant Chief
Engineering Division
Seattle District Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

Thank you for the opportunity to review the final draft report on Whitetail Dam (MT-118).

Our comments relating to specific report statements are:

Page 18, last sentence: The 30-inch diameter RCP is supported by a full length continuous cradle rather than a series of individual cradles, which are better known as pipe supports.

Page 37, last sentence: Without a more sophisticated study of the spillway hydraulics, to state that "the right sidewall of the spillway will be overtopped by splashing and wave action", requires more support. What is the freeboard above elevation 7256 without splashing or waves?

Page 41, item 4: Outlet stilling basin riprap has been rearranged and repaired.

Page 16, second paragraph: This statement certainly does not support the recommendation for a log boom.

Photo No. 11: Vegetation is slowly improving each year. It is the best that can be expected on these granitic soils.

We request that the meteorologic and hydrologic assumptions and conditions be fully presented and justified in the report.

We do not feel the meteorologic and hydrologic conditions used to develop the PMF are realistic. The conditions and criteria selected attempt to eliminate the element of risk to a degree that is not reasonable or practical.

We urge that a breach flood routing and thus a substantiated hazard classification be made in the Phase I inspection. With such a brief field overview, general hydrologic modeling and a subjective hazard analysis, the report is forcing the, as yet unjustified, economic burden of a Phase II inspection on the dam owners.

Sincerely,

Van K Haderlie
State Conservationist

cc:
Raymond J. Smith, State Conservation Engineer, SCS, Bozeman
Dave Jones, Environmental Engineer, SCS, Bozeman